DOCUMENT RESUME

ED 421 935 HE 031 458

AUTHOR Zhang, Zhicheng; RiCharde, R. Stephen
TITLE Assessing College Students' Development: A Repeated-Measures Analysis Using a Mixed Model.
PUB DATE 1998-04-00
NOTE 28p.; Paper presented at the Annual Meeting of the American Educational Research Association (San Diego, CA, April 13-17, 1998).
PUB TYPE Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Academic Achievement; *Cognitive Ability; College Students; Higher Education; Intellectual Development; Learning Processes; Longitudinal Studies; Males; *Metacognition; Self Control; Self Efficacy; *Study Skills; *Thinking Skills
IDENTIFIERS Repeated Measures Design

ABSTRACT

This study investigated students' metacognitive and intellectual development within the context of academic training, achievement, and personality type, using two longitudinal data sets from a four-year public institution. The first set included 408 male students of the 1996 cohort; the second was comprised of 419 male students of the class of 1997. The two cohorts were measured on three occasions: freshman matriculation, end of sophomore year, and immediately prior to graduation. Results of the study indicated that: (1) metacognitive development unfolds in a discontinuous pattern during the undergraduate years; (2) metacognition varies with academic training, with engineering students demonstrating a higher degree of metacognition than liberal arts majors, and science students outperforming engineering and liberal arts majors on problem solving; (3) metacognitive and intellectual development are fostered by academic achievement; students with higher grade point averages are less dependent on external forces for thinking and experience less uncertainty; (4) students become less absolute in thinking and less dependent on external forces as they progress through college; (5) students demonstrate increased confidence in their belief systems as they shift from a preference for clear-cut thinking to an understanding that events can be viewed from multiple perspectives; and (6) intellectual development varies with personality type. (Contains 34 references.) (CH)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED 421 935

Assessing College Students' Development: A Repeated-Measures Analysis Using A Mixed Model

Zhicheng Zhang
R. Stephen RiCharde
Virginia Military Institute

Paper presented at the annual meeting of
the American Educational Research Association
San Diego, April 13-17 1998

AE 031 458

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION
CENTER (ERIC)
This document has been reproduced as received from the person or organization originating it.
Minor changes have been made to improve reproduction quality.
Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY:

Zhicheng Zhang

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

Assessing College Students' Development: A Repeated-Measures Analysis Using a Mixed Model

The effects of the college experience extend far beyond academic learning. Different theories have been proposed to define student development in terms of knowing and valuing (Kitchener & King, 1981; Perry, 1970), moral reasoning (Kohlberg, 1975), and understanding of self in the subject-object relationship (Kegan, 1979; Loevinger, 1976). Since these theories examine college-student development within the context of a cognitive model, they are collectively labeled cognitive-developmental theories, though some argue that they extend into both affective and conative domains.

Numerous instruments have been developed within the framework of cognitive-developmental theories to measure intellectual development, moral development, ego development, and the ability to resolve developmental tasks. These include the Measurement of Intellectual Development (Knefelkamp, 1974; Widick, 1975), Reflective Judgment Interview (Kitchener & King, 1981), Defining Issues Test (Rest, 1979), Sentence Completion Test (Loevinger & Wessler, 1970), and Student Development Task Inventory-2 (Winston, Miller, & Prince, 1979). The past decade was marked by efforts to validate cognitive-developmental theories with female subjects and students of varying ethnic backgrounds.

Regardless of the terminology used by different theorists, one central focus of cognitive-developmental theories is intellectual development. Intellectual development in its many manifestations has been identified as a major goal of postsecondary education (Creamer, 1989). Barton (1959) maintained that the impact of a college education can be found in an individual's intellectual ability, knowledge, emotional and aesthetic experience, as well as values and commitments. Barton defined intellectual ability as the ability to think critically and independently. The goal of college training, regardless of academic discipline, is to teach students to think for themselves rather than transmitting a mass of information on a host of subjects.

Kitchener and Kitchener (1981) suggested that the intellectual domain may be broken down into two facets: logic reasoning and concepts of knowledge. Intellectual development is evident when inductive and deductive reasoning are combined in such a way that the individual forms and tests hypotheses and draws reasonable inferences. Empirical data suggest that college

students, like other adults, may have difficulty using correct deductive and inductive logical reasoning in some areas of problem solving because of lack of experience, interest, and expertise (Kitchener, 1982) and that their concepts of knowledge evolve discontinuously from a concrete assumption that knowledge is absolute and knowable by an authority figure to the abstract assumption that knowledge is uncertain (Kitchener & Kitchener, 1981; Perry, 1970).

Perry (1970) operationalized the concept of intellectual and ethical development into a model based on four categories: (1) dualism, characterized by rigid and dichotomous thinking; (2) multiplicity, a belief that there are multiple interpretations of the truth; (3)relativism, the realization that many possible answers exist; and (4) commitment, the ability to accept relativism while forming strong commitments to values and personal beliefs. Research using measures of Perry's scheme suggests that college seniors score in the high multiplicity to low relativism stages (King, 1978).

One component that is often included in the study of human cognition but has not been adequately integrated into the literature of student development is the concept of metacognition. Metacognition refers to one's awareness of his/her own cognitive processes or knowing what one knows (Gupta, 1992). The basic metacognitive strategies include connecting new information to previous knowledge, selecting thinking and problem-solving strategies deliberately, as well as planning, monitoring, and evaluating thinking processes (Blakey & Spence, 1990). Metacognition is an important cognitive functioning of the conscious mind in that it guides the entire problem-solving process from planning and implementing a strategy to evaluating whether a problem is solved satisfactorily (Blakey & Spence, 1990; Davidson, Deuser, & Sternberg, 1994). Thus, metacognition not only affects one's performance on a given task, but it may also lead to better future performance through self-reflection and self-evaluation.

According to the information-processing theory, metacognition is one of four areas in which cognitive development unfolds; the other three are attention, learning strategies, and the attainment of a knowledge base. As children mature, they demonstrate a greater degree of metacognition. This is reflected in their increasing awareness of the limitations of their memories, increasing knowledge of effective learning strategies, and increasing awareness of what they do and do not know (Flavell, Friedrichs, & Hoyt, 1970; Flavell, 1985; Ormrod & Wager, 1987).

Reflection on the feedback from experiences and subsequent abstraction of the results of the reflection into one's cognitive structures fosters metacognitive development (Gupta, 1992). Such a conceptualization implies that students can be taught cognitive strategies to improve metacognition and that metacognition continues to develop throughout college and adulthood. A variety of efforts have been made by educators to teach students metacognitive strategies (Blakey & Spence, 1990). More research is needed to explore how metacognition develops during college and into the later stages of adulthood.

Person-environment interaction theories represent another theoretical framework for college-student development. While cognitive-developmental theories focus on determining *what* kinds of development an individual has accomplished, the person-environment interaction theories attempt to find out *how* or under what circumstances development occurs in a college setting. Focusing on the effects of the person, the environment, and the interaction between the two, person-environment interaction theories propose that the probability of facilitating any kind of development (e.g., intellectual or moral) is a function of the interaction of a person with certain level of development in any given domain and the environment (Rodgers, 1990).

These two theoretical perspectives provide a range of epistemological foundations which have rarely been adequately reconciled. The cognitive developmentalists have anchored themselves on neo-Kantian dialectics as their theoretical bedrock while the person-environment interactionists have looked to Lockean empiricism for their traditional foundations. However, it is at the boundaries of the subject-object interaction that these positions find their closest link. This theme requires a brief elaboration to establish the theoretical underpinnings of the present study.

The cognitive developmentalists are best represented theoretically by Piagetian constructivism. According to Piaget, constructivism, as opposed to reductionism, is mainly concerned with how an organism can internally create something that did not previously exist. This form of constructivism was based on Godel's theorem that there must be a higher level to formalize the lower one which implies restructuring at the higher level. This lead Piagetian theorists to a form of realism in which the subject is influenced by the objects of consciousness or reality. These objects are observables which take their meaning only from the process of assimilation into cognitive schemes. Piagetians agreed with the physicist Foerster that objective

reality or the environment is what it is and contains no information on its own without processing by the subject. However, Piagetians disagreed with the traditional Kantian philosophy of *Ding an Sich* (also known as *noumenon* or "thing in itself") which states that the object is not only unknowable but unchanging. Piagetians believe that the object of consciousness is a constantly changing dynamic entity which becomes more sophisticated as the subject attempts to know it at a progressively higher level. This leads Piagetians to a dialectic interactionism between the subject and the object of consciousness which is best represented by Piaget's processes of assimilation and accommodation. Furthermore, it is here in this subject-object dialectic that the person-environment interactionists are most at home with Piagetian theory.

It is indeed the same dialectic interactionism that person-environment interactionists like Bandura are exploring in social-learning theory. The theoretical distinction comes at the borders of the subject-object interaction whereby Piagetians (already being dubbed Neo-Piagetians) (Papalia, Olds, & Feldman, 1998) are focusing on the subject in the subject-object interaction while the social-learning theorists are, in the tradition of empirical realism, focusing on the object in the subject-object interaction. This Neo-Piagetian stance has much in common with Vygotsky's *zone of proximal development*, and in this seam between subject and object there is room for a reconciliation of the process of learning with which both sets of theorists, the Piagetian and the person-environment interactionists, would feel at home.

The fact that the developing organism is changing and altering perceptions of the environment in discontinuous fits and starts is not an idea that Bandura would find abhorrent as might the radical behaviorist. Bandura's contextualist interactionism does not require the Piagetian reliance on evolutionary processes such as punctuated equilibrium nor does it require evolutionary stances such as "ontogeny recapitulates phylogeny" to accept the principle of discontinuous development. His parsimonious contextual philosophy in which the changing person is interacting with a changing environment and that latent learning is a viable principle is sufficient grounds to accept the discontinuity of the learning process. It is within this framework that the current study attempts to demonstrate the discontinuity of the development of cognitive processes and the relationship between person variables and achievement variables in a college population.

Following the traditional approach of the cognitive-developmental theories, the present study attempts to investigate students' metacognitive and intellectual development. The study also seeks to investigate metacognitive and intellectual development within the context of academic training, achievement, and personality type, an approach in line with person-environment interaction theories. The strengths of the study are in its use of a longitudinal design which includes metacognitive as well as intellectual constructs in the investigation of college-student development.

The study has two main objectives: depict the pattern of metacognitive and intellectual development over the course of the undergraduate experience; examine how metacognitive and intellectual development varies with academic training, achievement, and personality. Specifically, the study is conducted to test the following hypotheses:

1. Students experience a discontinuous metacognitive development as they progress through their college education.
2. Metacognitive development varies with academic training.
3. Metacognitive development is facilitated by academic achievement.
4. Intellectual development during college is marked by a decrease in dualism and relativism as well as a continuous increase in commitment and empathy.
5. Intellectual development varies with personality type.
6. Intellectual development is facilitated by academic achievement.

Methodology

Sample

Two longitudinal data sets from a four-year public institution were aggregated in the study. The first data came from 408 students of the class of 1996 and the second from 419 students of the class of 1997. The two cohorts were measured on three occasions: freshman matriculation, end of sophomore year, and immediately prior to graduation. After multiple files (collected on the three instruments and at three points in time) were merged, the sample size was reduced to 300 because of mortality due to transfer, dropout, and students' inconsistency in taking the tests. The ethnic makeup of the valid sample was 88% white, 6% Asian, and 5% Black. Approximately 31% of the participants majored in engineering, 15% in science, and 53%

in liberal arts. Due to the nature of the institution, all participants were male with an average age of 22 at the time of graduation.

Instruments

Data were collected on three instruments: the Learning-Thinking Styles Inventory (LTSI) (RiCharde, 1992), the Scale of Intellectual Development (SID) (Erwin, 1983), and the Myers-Briggs Type Indicator (MBTI). Seven variables were used to measure student development: logical reasoning, probability estimate, problem-solving approach, dualism, relativism, commitment, and empathy. The first three variables represent metacognitive development, and the last four operationalize intellectual development.

Logical reasoning, probability estimate, and problem-solving approach are the three composite variables derived from the LTSI which measures college students' learning and thinking styles on four subscales: (1) perceptual-modality preference, (2) distractibility, (3) metacognition, and (4) analytic versus global tendency. The LTSI was developed within the framework of the information-processing and trait theories and its reliability and construct validity have been established through empirical research (Zhang & RiCharde, 1997). Logical reasoning, probability estimate, and problem-solving approach are connected in the following way: logical reasoning is a measure of an individual's ability to solve seven analytical logic problems; probability estimate is a measure of how much metacognitive knowledge an individual has concerning his/her performance in solving the logic problems; problem-solving approach is a measure of the strategies used by an individual to solve the logic problems. Logical reasoning and probability estimate are measured with an objective technique whereas problem-solving approach is based on self-report data.

Dualism, relativism, commitment, and empathy are the four variables from the SID, an instrument designed to measure the intellectual development of college students (Erwin, 1983). The SID was based on Robert's (1977) Scales of Ethical and Intellectual Development which followed the same theoretical framework as William Perry's scheme of intellectual and ethical development, but the SID deviates from its original model by using an objective measurement technique and slightly modified stages.

The SID measures four stages of intellectual development: dualism (see issues in clear-cut,

black or white terms, look to authority for guidance), relativism (recognize the existence of alternative perspectives, inability to take a stand or lack of confidence in one's beliefs and actions due to the realization of multiple perspectives), commitment (make major decisions in their lives and accept the consequences of the decisions, tolerate other viewpoints), and empathy (make major life decisions and are aware of the impact of their decisions on other people, develop a sensibility about others and feel responsible for improving society in general). The four stages represent an increasing degree of intellectual sophistication. College seniors are expected to score higher on commitment and empathy than freshmen (Erwin, 1983).

Another instrument used in the study was the MBTI. The MBTI defines four basic categories of temperament: introvert (I) versus extrovert (E), sensing (S) versus intuitive (N), feeling (F) versus thinking (T), and judging (J) versus perceiving (P). Research indicates that personality type is associated with learning styles (Lawrence, 1993) and career choice (Hammer & Macdaid, 1992). Our experience with college students suggests that classification from the first two bipolar categories helps to predict performance in a college setting. Thus, in the present study we classified the participants based on their concatenated scores from the first two categories, resulting in EN, ES, IN, and IS as four personality types.

Data Analyses

Data were analyzed in a repeated-measures design using a SAS mixed model. A repeated-measures study refers to a design in which multiple measurements of a dependent variable are taken on the same experimental units. The experimental units in this case were the students; the dependent variables on which the students were measured three times were logical reasoning, probability estimate, problem-solving approach, dualism, relativism, commitment, and empathy. The three independent (treatment) variables were academic training as represented by major with three levels (engineering, liberal arts, science), academic achievement as measured by GPA with three levels (top 10%: GPA > 3.46; middle 40%: 3.46 > GPA >= 2.58; bottom 50%: GPA < 2.58), and personality as measured by the MBTI with four levels (EN, ES, IN, IS).

Academic major and GPA were each used as an independent variable in three separate repeated-measures analyses with each involving one metacognitive measure. GPA and personality were each used in four separate repeated-measures analyses with each involving one intellectual

measure. The focus of each analysis was to find out how the treatment means (for different levels of an independent variable) changed over time and whether there was a treatment-by-time interaction on each dependent variable (Littell, Milliken, Stroup, & Wolfinger, 1996).

The repeated-measures analyses were performed using a mixed linear model. The mixed linear model was used instead of the general linear model because the former permits the data to exhibit correlation and nonconstant variability, a problem often found in repeated measurements. The mixed linear model has the flexibility of modeling not only the means of data by using fixed-effects parameters (as in the general linear model) but their variances and covariances by using random-effects parameters as well (SAS/STAT Software, 1996).

Depending on the nature of the data, a variety of covariance structures may be used to handle correlation and nonconstant variability in a repeated-measures analysis, the most common of which are diagonal, compound symmetry, unstructured, or autoregressive. In the present study the spatial power law (SP(POW)) covariance structure was chosen to accommodate unequally spaced longitudinal measurements (Littell, Milliken, Stroup, & Wolfinger, 1996). The SP(POW) covariance structure assumes that the correlations of the repeated measurements are smaller for observations that are farther apart in time.

Maximum likelihood methods were used for parameter estimation. SAS produces Akaike's information Criterion (AIC) and Schwarz' Bayesian Criterion (SBC) for mode-fitting information. Data-to-model fit was evaluated by comparing models with the same fixed effects but different covariance structures. The covariance structure with values of the AIC or SBC criteria closest to zero was considered most desirable (Littell, Milliken, Stroup, & Wolfinger, 1996).

Results and Discussion

Data-to-model fit was evaluated by comparing the model-fitting indices from the recommended SP(POW) covariance structure and the alternative unstructured covariance structure. Results indicated that the AIC and SBC model-fitting indices from the two covariance structures were very close with the SP(POW) covariance structure producing slightly lower AIC index (e.g., -615 versus -611) and slightly higher SBC (e.g., -619 versus -622) index than the unstructured covariance structure. Since the SP(POW) covariance structure was the most

appropriate for the current data and its model-fitting indices were very close to those of the alternative model, all repeated-measures analyses in the study were conducted using the SP(POW) covariance structure.

Table 1 presents the means of metacognitive measures by major and GPA; Table 2 summarizes the means of intellectual measures by GPA and personality. To derive meaningful interpretation, the analysis results will be discussed around each hypothesis. Unless stated otherwise, time 1 is used for freshman matriculation, time 2 for the end of sophomore year, and time 3 for graduation. Tukey procedure was used for follow-up comparisons of means when main or interaction effects were found significant.

Hypothesis 1. The first hypothesis proposes that students experience a discontinuous development in metacognition as they progress through their college education. The testing of the hypothesis entails an examination of the within-subjects effects of time on the metacognitive measures. Table 1 shows significant within-subject effects over time on logical reasoning ($F_{(2, 573)} = 26.26$, $p < .001$ for major; $F_{(2, 571)} = 15.68$, $p < .001$ for GPA) and probability estimate ($F_{(2, 573)} = 7.89$, $p < .001$ for major; $F_{(2, 571)} = 5.08$, $p < .01$ for GPA).

Follow-up comparisons of the means from three measurement times indicated that students scored significantly lower on logical reasoning at time 2 than at time 1 and then scored significantly higher again at time 3 than at time 2. The mean at time 3 was higher than that of time 1, but the increase was not statistically significant. On the measure of probability estimate, the same discontinuous pattern of change was observed although the decrease from time 1 to time 2 was not statistically significant. The change on logical reasoning and probability estimate confirmed the hypothesized discontinuous development for metacognition which was marked by a temporary drop between freshman matriculation and sophomore year followed by an invariant increase during the last two years of college experience. Despite the discontinuous development over time, better performance was observed on both logical reasoning and probability estimate at time 3 as opposed to time 1.

The findings on logical reasoning and probability estimate lent support to the hypothesized discontinuous development in metacognition. The conclusion may be weaken by the fact that no significant change was observed over time on problem-solving approach. However, since

objective techniques were used with logical reasoning and probability estimate but not with problem-solving approach, it seems reasonable to rely more on the first two measures when drawing conclusions about metacognition.

Hypothesis 2. The second hypothesis assumes that metacognitive development varies with academic training. The testing of the hypothesis requires the examination of the between-subject effects of academic major on the metacognitive measures. As can be seen from Table 1, the hypothesis was born out by the significant between-subject effects of major on logical reasoning ($F_{(2, 327)} = 5.97$, $p < .01$), probability estimate ($F_{(2, 327)} = 9.28$, $p < .001$), and problem-solving approach ($F_{(2, 327)} = 13.14$, $p < .001$). Follow-up comparisons of the means indicated that, throughout the four-year period, engineering majors on the average scored significantly higher than liberal-arts majors on logical reasoning, probability estimate, and problem-solving approach; science majors scored significantly higher than both engineering and liberal-arts majors on problem-solving approach. These findings, while not sufficient to derive causal explanations, provided evidence for the notion that metacognitive development varies with academic training.

Hypothesis 3. The third hypothesis states that metacognitive development is facilitated by academic achievement. To test the hypothesis, we need to examine the between-subject effects of GPA on the metacognitive measures. Table 1 shows significant between-subject effects of GPA on logical reasoning ($F_{(2, 326)} = 11.47$, $p < .001$) and probability estimate ($F_{(2, 326)} = 13.09$, $p < .001$). Subsequent comparisons of the means revealed that, throughout the four-year period, the top 10% of the students scored significantly higher than the middle 40% and bottom 50% on both logical reasoning and probability estimate; the top10% of the students scored significantly higher than the bottom 50% on problem-solving approach; the middle 40% of the students scored significantly higher than the bottom 50% on metacognition. These findings were consistent with the hypothesis that metacognitive development is fostered by academic achievement.

Hypothesis 4. The fourth hypothesis postulates that as students progress through college education, their intellectual development is marked by a decrease in dualism and relativism as well as an increase in commitment and empathy. The testing of the hypothesis requires an examination of the within-subject effects of time on the four measures of intellectual development. Table 2 shows significant within-subject effects of time on dualism ($F_{(2, 323)} = 3.63$, $p < .05$ for GPA; ($F_{(3,}$

$_{561}$) = 5.79, $p < .01$ for personality), relativism ($F_{(2, 323)} = 4.29$, $p < .05$ for GPA; ($F_{(3, 561)} = 5.97$, $p < .01$ for personality), commitment ($F_{(2, 323)} = 23.68$, $p < .001$ for GPA; ($F_{(3, 561)} = 29.20$, $p < .001$ for personality), and empathy ($F_{(2, 323)} = 6.24$, $p < .01$ for GPA; ($F_{(3, 561)} = 11.64$, $p < .001$ for personality).

On the measure of dualism, the students scored slightly higher at time 2 than at time 1, followed by a significant decrease between time 2 and time 3. Given the nature of the institution where conformity to discipline and unitary thinking form the central component of freshman-year experience, the increase on dualism during the first two years should not be surprising. The eventual decrease on dualism suggested that the students became less absolute in thinking and less dependent on external forces for guidance as they progressed through college education.

On the measure of relativism, a continuous decrease throughout the four-year period was observed with the measure of time 3 being significantly lower than that of time 1. This was true in the analysis of both GPA and personality. Given the way relativism is operationalized by the SID items, the downward trend on relativism over time suggested that the students demonstrated an increasing confidence in their belief system and course of action as they shifted from a preference for clear-cut thinking to an understanding that events can be viewed from multiple perspectives. These findings provided evidence for the hypothesized continuous decrease on relativism.

Contrary to our hypothesis, a v-shape discontinuous increase on commitment and empathy was noticed. On both these measures, a significant decrease was noticed between time 1 and time 2. Then during the last two years at college the students demonstrated a significant increase in commitment, yet no significant improvement was observed on the measure between freshman matriculation and graduation. The v-shape discontinuous developmental trend on commitment and empathy seemed to reflect typical college experience marked by an initial period of shattering and questioning one's belief system followed by an eventual recovery where students reemerge with a rebuilt confidence and belief system. Different from our expectation, students did not outperform on commitment and empathy at time 3 than at time 1. One possible reason for this is that, at the time of senior testing (one month before graduation), the students experienced another surge of uncertainty due to the looming prospect of graduation and unknown changes lying ahead.

The findings from the present study indicated that college students' intellectual development is most obviously noticed in a reduced reliance on external guidance and less absolute thinking as reflected in decreased dualism as well as an increasing confidence in one's beliefs and actions as reflected in decreased relativism. In contrast, the development in commitment and empathy followed a more arduous process. Yet, the v-shape developmental trend on commitment and empathy lent support to the traditional notion that college is a time of awakening, a time of questioning one's views of life, a time of exploring different options, a time of expanding one's mind, and a time of rebuilding one's confidence and ideology (Erikson, 1968). The findings also seemed to suggest that intellectual development in terms of making major decisions about one's life and being aware of the impact of one's behaviors on others requires real-life experiences in addition to abstract reasoning and thinking often found in an academic environment. Until young people are loaded with the responsibilities that come with raising a family and developing a career, their commitment and empathy may not be fully developed.

Hypothesis 5. The fifth hypothesis states that intellectual development varies with personality type. To test this hypothesis, we need to examine the between-subject effects of personality on the four measures of intellectual development. Table 2 shows significant between-subject effects of personality on dualism ($F_{(3, 429)} = 4.51$, $p < .01$) and significant interaction effects of personality by time on relativism ($F_{(6, 561)} = 2.20$, $p < .05$). Follow-up comparisons of the means indicated that, throughout the four-year period, extrovert-sensing students scored significantly higher than extrovert-intuitive students on dualism. This finding suggests that, given the same extroversion propensity, sensing individuals are more likely to think in black or white terms and rely more on external forces for guidance than intuitive people.

Follow-up analysis of the interaction effects of personality by time revealed that, on the measure of relativism, extrovert-intuitive students experienced a significant decrease in the senior year as opposed to freshman matriculation or sophomore year. Extrovert-sensing students, in contrast, went through a period of temporary increase on relativism between freshman matriculation and sophomore year; followed by a significant decrease during the last two years. Once again the analysis results brought to light the differences in intellectual development between extrovert-intuitive and extrovert-sensing students. The difference may be caused by the

fact that sensing individuals are more responsive to external environment. The findings provided evidence for the hypothesis that intellectual development varies with personality type. Specifically, the data seemed to suggest that variability in dualism and relativism can be accounted for by the differences between EN an ES personality types.

Hypothesis 6. The sixth hypothesis proposes that intellectual development is facilitated by academic achievement. An examination of the between-subject effects of GPA is necessary to test the hypothesis. Table 2 shows significant between-subject effects of GPA on dualism ($F_{(2, 323)}$ = 3.40, $p < .05$) and relativism (($F_{(2, 323)}$ = 6.65, $p < .01$). Follow-up comparisons of the means revealed that, throughout the four-year period, the top 10% of the students scored significantly lower than the middle 40% and bottom 50% on dualism and relativism. These findings suggested that the students with higher academic achievement were less dependent on external forces for guidance and had few doubts about their beliefs and actions than their peers with lower academic achievement. Follow-up comparisons of the means also indicated that, throughout the four-year period, the top 10% of the students scored significantly higher on commitment than the bottom 50%, suggesting that higher achievers possess a greater ability to set goals and make decisions concerning education, occupation, and belief system than lower achievers. These findings were consistent with the hypothesis that intellectual development is facilitated by academic achievement.

Conclusion

The present study was an initial investigation of college students' metacognitive and intellectual development over the course of the undergraduate experience. Academic training, achievement, and personality were included in the investigation to determine how they influence metacognitive and intellectual development. A repeated-measures design was used on longitudinal data to map cognitive-developmental trends for college students.

In support of our hypothesis, metacognitive development during the undergraduate years unfolded in a discontinuous pattern. This was especially true in logical reasoning and probability estimate. As students progressed through their undergraduate experience, their metacognitive development was first marked by a decrease in logical reasoning and probability estimate in the first two years, followed by a significant increase on the same measures between the end of

sophomore year and graduation. This v-shape pattern of development mirrors the typical college experience at the initial stage of which students, stimulated by a newly-found freedom and expansion of their intellectual horizons, question and critique what they have embraced previously. This results in a period of ideological uncertainty and disintegration of old knowledge structures. Later as they move from the general-education distribution to more specialized training in their chosen disciplines, the leveling effects of the initial college experience are gradually replaced by a period of recovery when students emerge with a rebuilt confidence in their belief system, a more integrated knowledge base, as well as more sophisticated ways of thinking. Considering that metacognitive development is a direct result of metacognitive experience (Flavell & Wellman, 1977) which in turn is the product of constant reflection on schooling and intellectual experiences from which one abstracts and incorporates new cognitive structures (Gupta, 1992), it is reasonable to conclude that metacognitive development is a more complex process than knowledge acquisition. It follows that the metacognition demonstrated by college seniors differs qualitatively from that of freshmen in much the same way that metacognition emerges and changes in quality during the preoperational stage (called *abstraction reflechie* in Piagetian terms) (Piaget, 1976).

Metacognitive development was found to vary with academic training. Engineering majors demonstrated a higher degree of metacognitive development as measured by logical reasoning, probability estimate, and problem-solving approach than liberal-arts majors over the entire course of undergraduate education; science students outperformed engineering and liberal-arts majors on problem-solving approach over the four-year period. While these findings point to discipline-related differences in metacognitive development, they are not sufficient for causal explanations. Do students with higher metacognitive skills tend to choose engineering and science majors? Or does academic training in some fields of study foster logical reasoning, probability estimate and use of problem-solving skills more than others? Additional research is needed to answer these questions. Based on the present findings, it is safe only to conclude that the variability in metacognitive development can be accounted for by academic training.

In support of our hypotheses, metacognitive and intellectual development is facilitated by academic achievement. Students with higher GPAs outperformed their peers with lower GPAs on

all three measures of logical reasoning, probability estimate, and problem-solving approach. This finding clearly suggests a connection between metacognitive development and academic achievement (Flavell, 1985). The difference may exist because higher achievers more often exercise their metacognitive skills through reflection, self-evaluation, and conscientious abstraction of personal experiences. Students with higher GPAs also scored significantly lower than their lower-achieving peers on dualism and relativism, suggesting that higher achievers were less dependent on external forces for thinking and experienced less uncertainty and doubts about their beliefs and actions. Students with higher GPAs also demonstrated a higher degree of commitment characterized by an ability to set goals and make life-altering decisions. Once again the findings suggest a positive relationship between intellectual development and academic achievement. The data lent support to the notion that students with good academic standing possess a stronger ability to reason, think, and make decisions about personal and social issues than their peers and that this ability is central to metacognitive and intellectual development.

Personality variables were also found to be associated with intellectual development. A general difference was observed between extrovert-intuitive and extrovert-sensing types with the former scoring lower on dualism and relativism than the latter. This finding seems to suggest that, given the same propensity of extroversion, sensing individuals are more responsive to external environment, resulting in more dependence on authority figures for guidance and an increased feeling of uncertainty about their beliefs and actions during the first part of college experience. The study provides new evidence to support person-environment interaction theories.

In terms of intellectual development, the students in general demonstrated a decrease in dualism and relativism as well as a discontinuous increase in commitment and empathy over a four-year period. The decrease in dualism confirms previous research finding that, as student progress through their college experience, their intellectual development is marked by a shift from the assumption that knowledge is absolute and knowable by an authority figure to an understanding that knowledge is uncertain (Kitchener & Kitchener, 1981). The decrease in relativism further indicates students' increasing confidence in their belief system, actions, and choices while accepting multiple perspectives on social reality. Such an achievement reflects an understanding of not only where one stands in relation to others (Erwin, 1983) but also an

understanding of self in the subject-object relationship (Kegan, 1979; Loevinger, 1976).

Of particular interest was the finding that the repeated measures of commitment and empathy revealed a discontinuous developmental pattern rather than the continuous increase hypothesized. The v-shape pattern of change in commitment and empathy may be present for several reasons. First, the discontinuous developmental trend on these two measures parallels the typical college experience with its initial leveling effects and subsequent recovery of the students in both the cognitive and affective domains. Second, it is necessary to remember that dualism, relativism, commitment, and empathy represent an increasing degree of intellectual sophistication. In comparison to dualism and relativism, commitment and empathy entail more sophisticated thinking and reasoning in a broader context. Commitment involves setting goals and making a commitment in terms of career choice and ideology whereas empathy requires the consideration of the impact of one's actions on the lives of others manifested in such decisions such as marriage and starting a family. These issues not only demand a higher level of thinking, but also pressure students to consider real life beyond college. Many students may not be prepared to consider these issues in realistic terms or may not consider them at all. This partly explains the lack of variability by GPA and personality in empathy and by personality in commitment (see Table 2). Third, the phenomenon that scores on commitment and empathy at graduation did not exceed those at freshman matriculation may have been caused by the fact that the students in the sample experienced another surge of uncertainty at the end of the senior year because of the unpredictable future that lay beyond graduation. Will seniors perform differently on commitment and empathy if the testing date were to be pushed back to the first semester? How might graduate students directly out of the undergraduate years measure on commitment and empathy? Future research will be required to provide additional insight on these aspects of intellectual development.

The present study signifies a major advance in investigating student development. From a theoretical standpoint, the study of metacognitive and intellectual development in college students expands existing cognitive-developmental theories upon which much of the research on student development is based. The findings from the repeated-measures analyses of the longitudinal data add a new dimension to the current literature on intellectual development. The inclusion of

academic training, achievement, and personality allows educators to model both external and internal causes of variability in metacognitive and intellectual development.

References

Barton, A. H. (1959). Studying the effects of college education. New Haven, CT: the Edward W. Hazen Foundation.

Blakey, E. & Spence, S. (1990). Developing metacognition. Washington DC: Office of Educational Research and Improvement. ED 372 218.

Creamer, D. G. (1989). Changing internal conditions: Impact on student development. In W. L. Deegan & T. O'Banion (Eds.), Perspectives on student development (pp. 31-43). San Francisco: Jossey-Bass .

Davidson, J. E., Deuser, R., & Sternberg, R. J. (1994). The role of metacognition in problem solving. In J. Metcalfe & A. P. Shimamura (Eds.), Metacognition: Knowing about knowing (pp. 201-226). Cambridge, MA: The MIT Press.

Erwin, T. D. (1983). The Scale of Intellectual Development: Measuring Perry's scheme. Journal of College Student Personnel, 24, 6-12.

Erickson, E. H. (1968). Identity, youth and crisis. New York: Norton.

Flavell, J. H. (1985). Cognitive development (2nd ed.). Englewood Cliffs, NJ: Prentice-Hall.

Flavell, J. H., Friedrichs, A. G., & Hoyt, J. D. (1970). Developmental changes in memorization processes. Cognitive Psychology, 1, 324-340.

Flavell, J. H. & Wellman, H. M. (1977). Metamemory. In R. V. Kail & J. W. Hagen (Eds.), Perspectives on the development of memory and cognition (pp. 3-33). Hillsdale, NJ: Erlbaum.

Gupta, G. C. (1992). Ecology, cognition, metacognition and mind. Delhi: B. R. Publishing corporation.

Hammer, A. L. & Macdaid, G. P. (1992). MBTI career report manual. Palo Alto, CA: Consulting Psychologists Press.

Kegan, R. (1979). The evolving self: A process conception for ego psychology. The Counseling Psychologist, 8, 5-34.

King, P. M. (1978). William Perry's theory of intellectual and ethical development. In L. Knefelkamp, C. Widick, & C. Parker (Eds.), New directions for student services: Applying new developmental findings (pp. 35-51). No. 4. San Francisco: Jossey-Bass.

Kitchener, K. S. (1982). Human development and the college campus: Sequences and tasks. In G. R. Hanson.(Ed.), Measuring student development (pp. 17-45). San Francisco: Jossey-Bass.

Kitchener, K. S. & King, P. M. (1981). Reflective judgment: Concepts of justification and their relationship to age and education. Journal of Applied Developmental Psychology, 2, 89-116.

Kitchener, K. S. & Kitchener, R. F. (1981). The development of natural rationality. Can formal operations account for it? In J. S. Meacham & N. R. Santilli (Eds.), Social Development in Youth: Structure and Content (pp. 160-181). Basel, Switz.: Karger.

Knefelkamp, L. (1974). Developmental instruction: Fostering intellectual and personal growth in college students. Unpublished doctoral dissertation, University of Minnesota.

Kohlberg, L. (1975). The cognitive-developmental approach to moral development. Phi Delta Kappa, 56(10), 671.

Lawrence, G. (1993). People types & tiger stripes. Ocala, FL: Special Publications.

Littell, R. C., Milliken, G. A., Stroup, W. W., & Wolfinger, R. D. (1996). SAS system for mixed models. Cary, NC: SAS Institute Inc.

Loevinger, J. (1976). Ego development: Conceptions and theories. San Francisco: Jossey-Bass.

Loevinger, J. & Wessler, R. (1970). Measuring ego development. Vol. I: Construction and use of a sentence completion test. San Francisco: Jossey-Bass.

Ormrod, J. E. & Wagner, E. D. (1987). Spelling conscience in undergraduate students: Ratings of spelling accuracy and dictionary use. Paper presented at Northern Rocky Mountain Educational Research Association, Park City, UT.

Papalia, D. E., Olds, S. W., & Feldman, R. D. (1998). Human Development. San Francisco: McGraw-Hill Companies, Inc.

Perry, W. G. (1970). Forms of intellectual and ethical development in the college years: A scheme. New York: Holt, Rinehart and Winston.

Piaget, J. (1976). The grasp of consciousness: Actions and concept in the young child. Cambridge, MA: Harvard University Press.

Rest, J. R. (1979). Revised manual for the defining issues tests. Minneapolis: Moral research projects, University of Minnesota.

RiCharde, R. S. (1992). Learning-Thinking Styles Inventory. Lexington, VA: Virginia Military Institute.

Robert, M. J. (1977). Construction and validation of the scales of ethical and intellectual development. Unpublished manuscript.

Rodgers, R. F. (1990) Recent theories and research underlying student development. In D. G. Creamer and Associates (Eds.), College student development theory and practice for the 1990s (pp. 27-79). Alexandria, VA: the American College Personnel Association.

SAS/STAT Software: Changes and enhancements (1996). Cary, NC: SAS Institute, Inc.

Widick, C. (1975). An evaluation of developmental instruction in a university setting. Unpublished doctoral dissertation, University of Minnesota.

Winston, R. B., Jr., Miller, T. K., & Prince, J. S. (1979). Assessing student development. Athens, GA: Student Development Associates.

Zhang, Z & RiCharde, R. S. (1997, March). Learning-Thinking Styles Inventory: LISREL and Multivariate Analyses. Paper presented at the annual meeting of the American Educational Research Association, Chicago, IL.

Table 1
Repeated-Measures Analysis: Means of Metacognitive Development by Major and GPA

		Major						GPA					
		EN	LA	SC	$\bar{x}_{time}$	F1	F2		10%	40%	50%	$\bar{x}_{time}$	F1	F2
LR:	T1	4.39	4.04	4.40	4.27			T1	4.94	4.27	3.95	4.38		
	T2	3.93	3.39	3.69	3.64			T2	4.59	3.66	3.35	3.84		
	T3	4.73	4.21	4.65	4.52			T3	5.03	4.46	4.32	4.60		
	$\bar{x}_{Major}$	4.34	3.87	4.22				$\bar{x}_{GPA}$	4.85	4.12	3.85			
						26.26***	5.97**						15.68***	11.47***
PE:	T1	10.61	9.34	10.70	10.17			T1	12.47	9.98	9.25	10.54		
	T2	10.80	8.69	9.64	9.61			T1	11.55	9.63	8.92	9.99		
	T3	11.48	9.96	11.17	10.84			T3	12.38	11.01	9.90	11.08		
	$\bar{x}_{Major}$	10.90	9.32	10.40				$\bar{x}_{GPA}$	12.14	10.19	9.29			
						7.89***	9.28***						5.08**	13.09***
PS:	T1	8.48	8.36	9.09	8.64			T1	8.72	8.64	8.31	8.56		
	T2	8.63	7.55	9.33	8.52			T2	9.21	8.40	7.67	8.44		
	T3	8.32	7.73	9.10	8.38			T3	8.62	7.95	8.22	8.26		
	$\bar{x}_{Major}$	8.47	7.89	9.18				$\bar{x}_{GPA}$	8.86	8.33	8.07			
						.74	13.14***						.76	3.12*

EN = Engineering; LA = Liberal Arts; SC = Science. 10% = Top 10%; 40% = Middle 40%; 50% = Bottom 50%.
T1 = Freshman measure; T2 = Sophomore measure; T3 = Senior Measure.
F1 = F value for within-subject effects; F2 = F value for between-subject effects.
LR = Logical Reasoning; PE = Probability Estimate; PS = Problem-Solving Approach.
$\bar{x}_{major}$ = mean of academic major; $\bar{x}_{GPA}$ = mean of GPA. * $p < .05$; ** $p < .01$; *** $p < .001$. N = 300

Table 2
Repeated-Measures Analysis: Means of Intellectual Development by GPA and Personality Type

		GPA						Personality Type							
		10%	40%	50%	$\bar{x}_{time}$	F1	F2		EN	ES	IN	IS	$\bar{x}_{time}$	F1	F2	F3
D:	T1	86.00	88.06	89.93	88.05			T1	81.97	89.85	82.35	90.11	86.07			
	T2	83.43	91.00	92.42	89.21			T2	88.89	94.62	86.14	91.24	90.41			
	T3	79.21	88.72	86.47	84.73			T3	82.56	87.65	86.91	87.53	86.15			
	$\bar{x}_{GPA}$	83.09	89.20	89.70				$\bar{x}_{PT}$	84.48	90.84	85.36	89.49				
						3.63*	3.40*							5.79**	4.51**	
R:	T1	56.61	62.25	62.44	60.48			T1	63.44	59.90	61.02	61.14	61.37			
	T2	51.29	61.22	62.62	58.67			T2	62.62	63.57	58.00	59.84	61.12			
	T3	53.21	58.22	57.72	56.37			T3	55.44	56.84	60.06	58.01	57.61			
	$\bar{x}_{GPA}$	53.96	60.50	61.06				$\bar{x}_{PT}$	60.67	59.97	59.93	59.57				
						4.29*	6.65**							5.97**	.16	2.20*
C:	T1	126.74	122.74	123.67	124.33			T1	124.87	122.76	122.18	121.92	122.93			
	T2	120.39	115.70	112.79	115.92			T2	114.30	113.93	119.24	112.91	114.62			
	T3	128.33	123.19	121.69	124.32			T3	123.93	123.65	121.03	123.45	122.72			
	$\bar{x}_{GPA}$	124.93	120.38	119.26				$\bar{x}_{PT}$	120.61	119.93	120.50	119.33				
						23.68***	2.97							29.20***	.20	
E:	T1	81.16	79.06	80.45	80.20			T1	82.22	79.25	79.49	79.11	80.02			
	T2	79.36	74.86	75.49	76.29			T2	75.83	76.19	76.62	73.85	75.48			
	T3	81.21	78.73	78.03	79.29			T3	79.04	80.02	78.91	78.10	78.95			
	$\bar{x}_{GPA}$	80.45	77.46	77.86				$\bar{x}_{PT}$	78.80	78.39	78.38	77.02				
						6.24**	1.49							11.64***	.82	

10% = Top 10%; 40% = Middle 40%; 50% = Bottom 50%.
EN = Extrovert-Intuitive; ES = Extrovert-Sensing; IN = Introvert-Intuitive; IS = Introvert-Sensing.
D = Dualism; R = Relativism; C = Commitment; E = Empathy.
T1 = Freshman measure; T2 = Sophomore measure; T3 = Senior Measure.
F1 = F value for within-subject effects; F2 = F value for between-subject effects; F3 = F value for time-by-personality interaction effects.
$\bar{x}_{pt}$ = mean of personality type. * $p < .05$; ** $p < .01$; *** $p < .001$. N=300.